PREDICTION OF PERFORMANCE AND SATISFACTION OF AERONAUTICAL ENGINEERING STUDENTS AT THE NAVAL POSTGRADUATE SCHOOL

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THESIS

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by

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The primary objectives of this research project were the development of predictors of academic performance and satisfaction for Aeronautical Engineering students at the Naval Postgraduate School. The three basic types of data used to develope predictors were biographical (historical) academic aptitude (Graduate Record Exam), and individual interests (Strong Vocational Interest Blank) data. Several successful predictors of performance were developed but none of the predictors of

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Prediction of Performance and Satisfaction of Aeronautical Engineering Students at the Naval Postgraduate School

by

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ABSTRACT

The primary objectives of this research project were the development of predictors of academic performance and satisfaction for Aeronautical Engineering students at the Naval Postgraduate School. The three basic types of data used to develope predictors were biographical (historical), academic aptitude (Graduate Record Exam), and individual interests (Strong Vocational Interest Blank) data. Several successful predictors of performance were developed but none of the predictors of satisfaction cross-validated at a statistically significant level. Additional work will be required to successfully predict student satisfaction.

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I. INTRODUCTION

A. PURPOSE OF STUDY

The purpose of this research project was to develop a valid, scientifically based procedure for the selection of Naval Officers for postgraduate education in the Aeronautical Engineering Curriculum at the Naval Postgraduate School (NPS). The primary emphasis of this study was the prediction of academic performance at NPS, and the secondary emphasis was the prediction of satisfaction of these personnel should they enter this curriculum.

This project was a portion of the NPS Student Selection Project funded by the Navy Personnel Research and Developement Center, San Diego. The products of this study should provide additional procedures for both selection of personnel for the NPS Aero Program and for counseling of those personnel who have been selected.

B. PRESENT SELECTION PROCEDURES

1. General Description

The current process of selecting Naval Officers for postgraduate education begins with a forecast by CNO (OP01BE) of P and S coded billet requirements. The number of personnel who will be recommended for postgraduate education is then determined by subtracting the number "on board" from the number required. Finally, the Chief of Naval Personnel, using this and other information, determines the postgraduate education quotas by year group, designator and subspecialty required. A more detailed description of this procedure is provided by R. S. Elster [1].

These quotas are then sent to the Selection Board which is composed of NPS officials and ranking military officers. The Board performs its mission of choosing those officers to be recommended for postgraduate education in accordance with policies established by the Secretary of the Navy [2].

The Selection Board initially screens an officer for the curriculum of his first choice. Failing that selection the officer is then screened for the curriculum of his second choice. This process continues until the officer is considered for his third and final choice. A flow chart depicting this procedure is provided in ref. 1.

The results of the Selection Board's activities are recorded in a single digit alpha code as shown below:

CODE	MEANING
S	Recommended Selectee
R	Rejected
M	Returned to recorder for missing data
P	Principle Selectee
A	Alternate Selectee
T	"TRADEOFF"

Finally, a list of principle and alternate selectees is sent to the Detailing Section of BUPERS. The Detailer must then decide which of these personnel to send to NPS. His decision is based on such considerations as supply and demand of officers in each designator, planned rotation dates, and promotion possibilities.

2. General Selection Criteria

The present selection process is based primarily on two criteria: prior military (operational) performance and prior academic achievement. Past performance is weighted approximately 60% and is translated into a single digit number from zero to nine with zero being the highest possible rating. This number is derived from item 18(a) of an officer's Report of Fitness [3].

A person's prior academic achievement is weighted 40% in the selection process and is ultimately translated into an Educational Potential Code (EPC) [4]. The EPC is based on a scale of one through eight and is described below:

EPC	MEANING
1	Capable of direct entry into a technical curriculum
2	Capable of direct entry into a non-technical graduate program not requiring mathematical aptitude
3	Potentially capable of entry into a technical curriculum after a refresher course of 3 - 6 months duration
4	Capable of direct entry into a non-technical graduate program requiring some mathematical aptitude
5	Capable of entry into an updating program which may lead to qualification for a technical curriculum after 6 - 12 months of study
6	Capable of qualifying for category 5 by taking off-duty courses
7	No apparent potential for graduate education
8	No accredited baccalaureate degree. Needs undergraduate program.

The EPC is determined by the officer's undergraduate math and science courses completed, by his QPR in these courses, and by his cumulative undergraduate QPR. Specific requirements for these EPC's are provided in Appendix A.

The EPC is computed for all Naval Academy and ROTC personnel by NPS shortly after these officers have received their baccalaureate degrees. Other officers are assigned an EPC when they are first considered for postgraduate education.

There are several problems with the EPC as it is now used. First, the EPC may become outdated in a relatively short period of time for those who have continued their education after receipt of their baccalaureate degrees. In addition, the EPC does not allow for variances in quality of education received at different colleges and universities. Finally, the EPC does not reflect achievement in service schools.

3. Specific Criteria for Aeronautical Engineering

Officers may enter the Aero-Engineering Curriculum either directly or via the Engineering Science Program which is an intermediate level curriculum designed to strengthen the math and science backgrounds of those enrolled. Requirements for direct entry are an expressed desire for Aero, an EPC of 1, reasonable promotability, and membership in the aviation community (Pilot or NFO). Requirements for entry into the Aero Program via the Engineering Science Curriculum are similar to those for direct entry except for the EPC which may be either 3 or 5. Near the end of the Engineering Science Program students desiring the Aero Curriculum are screened for that program by Aero officials at NPS.

II. BASIC METHODOLOGY AND SAMPLE GROUP

A. CONCURRENT VALIDITY METHOD

This study was conducted using the Concurrent Validity Model [5] for the development of personnel selection procedures. This method is also referred to as the Present Employee Method [6] due to its use of present employees for both predictor development and validation. The basic steps which are sometimes involved in this procedure are listed below:

1 Job Analysis

2 Hypothesis Development

3 Predictor Development

4 Administration of predictors to sample group

5 Correlation of predictors with criterion in developmental portion of sample

6 Cross validation of predictors with criterion of cross validation portion of sample

7 Recommendation for selection

1. Primary Advantage of the Concurrent Validity Method

The principle advantage which this method offered over the more traditional "Follow-up Method" [6] was that of significant time savings. The predictors were developed with a portion of the presently enrolled students and then cross-validated with the remaining portion of the sample group. The follow-up method would require the predictors to be developed with present enrollees, administered to new applicants, and, finally, checked for validity after these applicants had been enrolled long enough to establish a measurable performance criterion.

The author began this project at the fifth step of the Concurrent Validity method. The hypothesized predictors were developed by Professors R. S. Elster and R. A. Weitzman and a comprehensive literature search was conducted by Professors J. D. Senger and R. S. Elster [7].

2. Primary Disadvantage of the Concurrent Validity Method

A major problem inherent in this method is that of restriction of range or curtailment. For example, those officers who are currently enrolled in the Aero Program compose a much smaller and more select group of individuals than those who were initially considered for the program. The 91 officers in the sample group have already been subjected to two screening processes. The first was based on operational performance and academic aptitude/achievement and the second on academic achievement during their first two quarters at NPS. Thorndike states "...the reduction of the validity of a test within a selected group becomes greater the more closely the test correlates with the basis of selection." [8]

B. SAMPLE GROUP

The sample group (S) was composed of 91 aero-engineering students who were at various stages in the aero program at NPS when the data were collected (Quarter 3, Academic Year 73-74). A stratified random sample composed of 61 students (S_1) was chosen from group S for the development of predictors of performance and satisfaction. The sample was stratified with respect to the number of quarters completed in the Aero Curriculum. The remaining sample (S_2) was, therefore, composed of 30 students and constituted the cross-validation sample. Due to missing Strong Vocational Interest Blank

Data for two persons, S was reduced to 89 and S_1 to 59 when analysis was done using these particular data.

As the project progressed it became apparent that different predictors might exist for those students who entered directly into the Aero program as opposed to those who entered via the Engineering Science Curriculum. A subdivision of groups S_1 and S_2 was made to explore this possibility.

Therefore, groups S_{11} and S_{12} became the developmental samples for direct entry and engineering science personnel respectively. Similarly, groups S_{21} and S_{22} became the cross-validation samples for direct entry and engineering science personnel respectively. A description of the sample formation procedures is displayed in Appendix B.

III. DATA

A. GENERAL

The data used in this project are categorized into three groups: biographical (historical) data, academic aptitude data, and individual interest data. The biographical data were acquired both by self reporting and by document search methods. The academic aptitude data were obtained by testing S with the Graduate Record Exam and the individual interest data by administration of the Strong Vocational Interest Blank.

B. BIOGRAPHICAL DATA

1. Self Reported

The self reported biographical data were acquired by administering a biographical questionnaire to S during quarter 3 of Academic Year 73-74. This questionnaire was specially designed by Professor R. A. Weitzman with assistance from J. L. Cook. Appendix C provides a list of the questions contained therein as well as a breakdown of the yes/no answers for each question. These answers were translated into quantifiable form as follows:

Answer	Value
Yes	1
No	0

Many of the questions were eliminated from the study for reasons such as lack of face validity [9], zero yes or no answers, and non-acceptability to the Navy. For example, questions as to weight, height, or number of daughters do not appear to be related to academic performance on the "face" of the issue. Additionally, questions with all yes or all no answers would provide no correlation between predictor and performance criterion since one of the variables would have no variance. Finally, questions related to such items as race and religion would not be acceptable to the Navy as a means of selecting graduate students.

The number of questions considered useful by the investigator was reduced to 16. These are listed below:

Question #	Variable #	Question
1	001	Did you receive your commission from USNA?
2	002	Did you receive your commission from an ROTC Program?
3	003	Have you ever been an enlisted man?
4	004	Is your rank lieutenant or below?
9	005	Do you have a B. S. Degree?
10	006	Have you had at least one year of college calculus at an institution other than NPS?
11	007	Do you speak at least one language other than English?
15	011	As an undergraduate in college, did you have an A or A- average?
16	012	Was your undergraduate average below B-?
22	013	Was a branch of engineering your undergraduate major in college?
44	014	Are you younger than 30 years of age?
47	015	Do you wish to serve in a billet requiring the education that you would receive at graduate school?
55	016	Are you satisfied with your education at NPS?
56	019	Are you in the curriculum of your 1st or 2nd choice?
59	017	Do you now like your degree curriculum?
60	018	Would you choose a different degree curriculum if you could start over again?

Additional variables which were derived totally or partially from the self reported data are Baccalaureate QPR (BQPR), Satisfaction (SN), College Quality (QUAL) and INDEX.

BQPR was extracted by using the answers to questions 15 and 16 of the questionnaire. Combinations of these two answers were converted to a four point QPR scale in the following manner:

Answer to #15	Answer to #16	BQPR
Yes	No	3.70
No	No	3.00
No	Yes	2.30

This approach to obtaining BQPR was used because the specific BQPR's may not have been known by the students being queried.

The criterion measurement of satisfaction was derived from the answers to questions 47, 55, 59 and 60. The responses to those questions were converted into a value of either zero or one as described below.

Question #	Response = Value	Response = Value
47	Yes = 1	No = 0
55	Yes = 1	No = 0
59	Yes = 1	No = 0
60	No = 1	Yes = 0

The SN rating for each individual was obtained by adding these four values. Therefore, SN became a whole number with a possible range of zero through four, with higher values indicating higher satisfaction.

College Quality (QUAL) is a rating of colleges and universities which is derived from the mean Scholastic Aptitude Test (SAT) scores of freshmen admitted to 988 colleges and

universities in the United States [10]. Therefore, QUAL is a three digit number with a possible range of 130 to 270.

The variable entitled INDEX was derived by multiplying each individual's QUAL by his BQPR. Thus, INDEX has a possible range of 260 to 1080.

2. Historically Documented Data

The variables which were acquired thru search of documents are listed below:

Variable	Meaning
ZQPR	Present Standardized QPR at NPS
CUS	Number of undergraduate courses completed which are pertinent to Aero-Engineering
PQPR	QPR in these pertinent courses
QPR3	Next to last year undergraduate QPR
QPR4	Last year undergraduate QPR
ABQPR	Actual overall undergraduate QPR

The performance criterion used in this study was present QPR at NPS. This presented a slight problem in that the grading system in the Aero-Engineering Department has been a 3 letter system (S,G,H) since 1971. The conversion of these letters into a 4 point QPR system was made in the following manner:

Symbol	Meaning	Value
S	Satisfactory	2.00
G	Graduate	3.00
H	Honors	4.00

This information was then transformed into a standardized QPR (ZQPR) so that future comparisons among different curriculum would be more meaningful. Therefore, the ultimate performance criterion used in this project was ZQPR.

The undergraduate courses which were considered pertinent to Aero-engineering were math, physics and Aero courses. These particular areas and only these areas were chosen as a result of an interview between the investigator and Professor R. D. Zucker, Academic Associate, Aeronautical Engineering Curriculum. The cumulative QPR in these pertinent courses (PQPR) was recorded at the same time as CUS.

The third and fourth year baccalaureate QPR's (QPR3, QPR4) were considered possible predictors of performance by the author due to success with these predictors reported by J. L. Cook [4].

Finally, the actual baccalaureate QPR (ABQPR) was recorded primarily to provide a comparison with self reported baccalaureate QPR. A discussion of this comparison is presented in the Ancillary Analyses section of this report.

C. ACADEMIC APTITUDE/ACHIEVEMENT DATA

The Graduate Record Exam [11] was used to obtain a measure of verbal and quantitative aptitudes of individuals within S. It was administered at NPS during quarter 3 of Academic Year 73-74. The range of possible scores for both Verbal and Quantitative sections is from 250 to 850. The scores obtained by S were recoreded on IBM data cards, as were the other data, and had the following variable names:

Name	Meaning
VERB	Verbal Aptitude Score
QUAN	Quantitative Aptitude Score

Numerous studies have been conducted which have shown significant correlations between GRE scores and academic performance. Many of these studies are listed in Refs. 12 and 13.

The Undergraduate Program Exam (UP) was designed to "provide information useful in assessing individual achievement in undergraduate work and competence for further study" [14]. This test is also composed of two parts, verbal and quantitative, and has the same range of possible scores as the GRE. Although this exam was not administered for use in this study, UP data were available for a portion of S due to testing practices which were already established at NPS. Comparisons of the UP and GRE data are discussed in the Ancillary Analyses section of this thesis.

D. INDIVIDUAL INTEREST DATA

An inventory of individual interests of those officers in S was obtained by use of the Strong Vocational Interest Blank (SVIB), form T-399 (Revised 1966). It was given to S during the same general time period as was the GRE. The SVIB compares the testee's interests with those of a large sample of individuals in each of 56 different professions. In addition, nine non-occupational scale scores are provided by the SVIB. A list of 55 occupational scales and the 9 non-occupational scales that were used in the study is provided in Appendix D. All SVIB scale scores used in the development of predictors were the standardized, vice the raw, scores.

IV. ANCILLARY ANALYSES OF DATA

A. GENERAL

Preliminary analyses of the previously described data were conducted prior to the development of predictors. Several areas which proved to be of particular interest to the researcher were the BQPR/ABQPR data, the longitudinal stability of TQPR's (Total Quality Point Ratings while at NPS), the TQPR's of Naval Academy graduates/Non-Naval Academy Graduates, and the GRE/UP data.

1. BQPR/ABQPR Data

The data constituting BQPR consisted of three specific values which were related to the continuous four point QPR scale as follows:

BQPR	FOUR POINT SCALE
2.30	2.00 - 2.59
3.00	2.60 - 3.39
3.70	3.40 - 4.00

Since the BQPR and ABQPR were segmented and continuous respectively, a triserial correlation [15] was computed. The resulting correlation was $r_{tri} = 0.78$. An explanation of this correlation computation and a listing of matched BQPR/ABQPR data are provided in Appendix E.

Due to the disparities between these two groups of data, predictor development was conducted in two phases. One phase was completed with all data except BQPR and INDEX and the other was done with all data except ABQPR. In other words, both self-reported and documented undergraduate QPR data were not used simultaneously.

2. Longitudinal Stability of TQPR

The Aero Engineering sample (S) was composed of groups of students who had been enrolled in that curriculum for one, three, five, seven, and nine quarters respectively. T. A. Welch pointed out two primary reasons for the importance of the stability of TQPR's from quarter to quarter [16]. First, instability of individual TQPR's would indicate that different variables may be needed to predict these TQPR's in different quarters. Therefore, one predictor system may not be applicable to the students during their entire enrollment period in the Aero Program.

Additionally, if longitudinal stability of TQPR's exists, a students performance during his first few quarters would be indicative of his academic performance throughout his enrollment.

A very high degree of longitudinal stability for the Aero Engineering TQPR's was reported in Ref. 16 and is displayed in Table I.

TABLE I

LONGITUDINAL STABILITY OF TQPR

QUARTERS COMPLETED				
	1	2	3	7
1	1.00	0.94	0.93	0.87
2		1.00	0.98	0.90
3			1.00	0.92
7				1.00

3. Naval Academy/Non-Naval Academy TQPR's

A comparison of TQPR's for these two subgroups of S was made because the Naval Academy predictor variable (VAR001) appeared as a negatively weighted factor (predicted lower TQPR for those who attended USNA) in several of the formulae developed within this thesis for the prediction of performance. The student t test [17] was used to make this comparison and showed that there was no statistically significant difference between the TQPR's of these two groups. However, a slightly lower mean TQPR did exist for Naval Academy graduates. The results of this comparison are listed in Table II.

TABLE II

TQPR: USNA VS NON-USNA

NAVAL ACADEMY	OTHERS
N = 37	N = 54
MEAN TQPR = 3.11	MEAN TQPR = 3.21
SD = 0.30	SD = 0.30

t = -0.11

4. GRE/UP Data

Two types of comparisons of these data were made using the student t test for significant difference. The first of these was a comparison of both GRE and UP scores of direct entry students with those of engineering science students. It should be noted that all personnel received the UP exam when they were in their first quarter of the Aero Program whereas the GRE exam was given to S during quarter three, academic year 73-74. This resulted in an average time in curriculum of approximately five quarters for those taking the GRE exam. The results of the first comparisons showed no significant differences (at the .05 level) in either UP or GRE scores for these two groups.

Secondly, a longitudinal comparison of individuals' GRE and UP scores for each of these two groups of students was made. According to an Education Testing Service Study [14] , the scores on the GRE and UP exams may be directly equated, thus making such a comparison possible. The only significant difference (.05 level) which was found was between the quantitative GRE and UP scores for the direct entry group. This would appear to indicate that the quantitative aptitudes of these students improved after they had been in the Aero Curriculum for a while.

The first comparison showed no significant difference in the GRE scores of the Engineering Science versus the direct entry groups while the second comparison indicated that only the direct entry students improved in quantitative aptitude while enrolled in the Aero Curriculum. These two findings, when considered together, tend to support indirectly the hypothesis that the Engineering Science Curriculum did improve the quantitative aptitudes of those who were enrolled. Graphs showing these results are provided in Appendix F.

V. DATA ANALYSIS

A. GENERAL

The primary analysis of the data was conducted using two packaged computer programs at the W. R. Church Computer Center at NPS. These programs, specifically designed for analysis of social science data, were the Statistical Package for the Social Sciences (SPSS) and the Introduction to Exploratory Data Analyses (SNAP/IEDA, henceforth referred to as SNAP).

The SPSS program was developed by social scientists at Stanford University and is currently maintained and distributed by the National Opinion Research Center at the University of Chicago [18]. SPSS was used in this thesis to provide Pearson correlations, multiple regression, and stepwise (order predetermined) multiple regression. Additional information on this program may be found in Ref. 19.

The SNAP Program was developed at Princeton University for basic statistical analysis with a specific type computer. It was used in this thesis to obtain Pearson R's and scatter plots of the data. The scatter plots were used to provide a check for curvelinear relationships and to provide information with which to construct expectancy charts [20]. Additional information on this program may be found in Ref. 21.

The objectives of the analysis were the prediction of academic performance (ZQPR) and satisfaction (SN). The predictors were developed and cross validated using the Pearson product moment correlation [22]. After cross validation of these predictors, the

weights of the variables contained in the predictor formulae were refined by using the entire pertinent sample group (developmental + cross-validation) and stepwise multiple regression. This was considered necessary due to the small sample size involved. Analysis was conducted separately using each of the three basic types of data (biographical, GRE, SVIB). Then, combinations of these data were analyzed for their predictive capabilities.

A listing of the correlations of all predictor variables with each of the two criterion variables (ZQPR and SN) is provided in Appendix G.

B. PREDICTORS OF PERFORMANCE

The only predictor systems which are reported in this thesis are those which cross-validated at the .05 level of significance or better. The refined formulae for these predictors, as well as institutional and individual expectancy charts are included herein.

The expectancy charts were constructed by dividing the actual performance criterion scores (ZQPR's) into two portions (at the median), and the predicted ZQPR's into quintiles. The institutional expectancy chart displays the expected percentage of superior performers (TQPR above current sample's median) in the top 20, 40, 60, 80 and 100 percentile groupings of the predicted ZQPR's. The individual expectancy chart displays an individual's chances in 100 of being superior for the quintile with which his predicted ZQPR coincides. A detailed description of this type of chart and its construction is provided by Bolda and Lawshe [20].

The predictors which cross-validated at the .05 level of significance are so indicated with a single asterisk (*) and those

which cross-validated at the .01 level of significance are so indicated with a double asterisk (**).

Since the performance criterion used in this research was standardized QPR (ZQPR), the predicted QPR's were also standardized scores. Thus, a conversion of these standardized values back to raw TQPR's was made. Therefore, the formulae for performance predictors are presented in two parts: the predictor formula for ZQPR, and the formulae for converting ZQPR to raw TQPR. The procedures for making this conversion are described by McNemar [23].

Finally, it should again be noted that all SVIB scale scores used in predictor development were the standardized, rather than the raw, scores.

1. Biographical Data

a. Whole Sample Group (S_1 and S_2)

(1) Statistics

Table III displays the Pearson product moment correlations (R values) between the predicted ZQPR's and the actual ZQPR's for the developmental group (DEV R), the cross-validation group (X-VAL R), and the entire sample group (REFINED R), respectively. It can be seen that the only predictor system which cross-validated at the .01 level of significance was the one containing four variables. These variables included INDEX (BQPR x QUAL), VAR001 (Naval Academy Graduate), VAR004 (LT or below) and VAR005 (B.S. Degree).

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[1] "raw TQPR" is the grade average appearing on the student's transcript.

TABLE III

· PREDICTED ZQPR CORRELATIONS WITH CRITERION VARIABLE (ZQPR)

VARIABLE	STEP #	DEVELOP R	X - VAL R	REFINED R
VAR004	1	.30*		
INDEX	2	.38**		
VAR001	3	.47**	.43*	
VAR005	4	.50**	.48**	.48**
BQPR	5	.52**	.46*	
QUAL	6	.61**	.43*	
VAR014	7	.87**	.41*	
VAR013	8	.96**	.39*	
DEGREES FREEDOM		55	26	83

(2) Formulae

The necessary constant and the weighting factors for the four predictor variables are shown in Formula I. It may also be seen that VAR001 is negatively weighted in this equation. A discussion of this occurrence in several of the predictors of performance is presented in the Ancillary Analysis Section of this thesis.

Formula I

Predicted ZQPR = X

$$X = -1.026 + 0.00251\ (INDEX) - 0.519\ (VAR001) + 0.635\ (VAR004) - 0.85\ (VAR005)$$

The basic formula for converting predicted ZQPR to raw TQPR is provided by Formula II-A. Formula II-B is a simplified and condensed version of this same equation.

Formula II-A

Converted ZQPR = RT

$$RT = \frac{S'}{S}(X) - \frac{S'}{S}(M) + K$$

K = mean actual raw QPR = 3.188

S' = S D actual raw QPR = 0.309

M = mean predicted ZQPR = 0.002

S = S D predicted ZQPR = 0.472

Formula II-B

$$RT = 0.655(X) + 3.187$$

(3) Expectancy Charts

Chart I is referred to as an "institutional" expectancy chart because the information it provides is more readily used by an organization than by an individual. It displays the percentage of students who are expected to be superior (to attain a TQPR above the current median) should the organization choose the top 20, 40, 60, 80, or 100% of the applicants.

The "min raw TQPR's" are the cutoff scores for the five cumulative groupings mentioned. Therefore, it can be seen that 82% of the students whose predicted raw TQPR's are 3.40 or above are expected to "be superior."

CHART I

INSTITUTIONAL (CUMULATIVE) EXPECTANCY CHART

Group	Min. Raw TQPR	Per Cent That Will Be Superior (Above Current Median Raw TQPR)
Best 20%	3.40	82%
Best 40%	3.19	70%
Best 60%	3.14	63%
Best 80%	2.86	56%
ALL	No Min. TQPR	50%

The individual expectancy chart should be of value to the individual officer who is considering enrollment in the Aero Curriculum. It may also provide a useful counseling tool for the Aero Department. Chart II displays a students probability of attaining a superior performance according to his predicted TQPR. It can been seen that an officer whose predicted raw TQPR is 3.00 would have a probability of .35 of being superior in performance.

CHART II

INDIVIDUAL EXPECTANCY CHART

Predicted Raw TQPR	Chances In 100 Of Being Superior (Above Current Median Raw TQPR)
≥3.40	82
3.19-3.39	59
3.14-3.18	47
2.86-3.13	35
<2.86	29

2. GRE Data

The developmental formulae using only GRE data for groups S_1, S_{11}, and S_{12} did not cross-validate at a significance level of .05 or better. It was hypothesized that the restriction of range problem which has been previously discussed is the primary reason for this occurrence.

3. SVIB Data

The SVIB Data provided the highest cross-validated predictor systems for predicting performance of any of the three basic types of data used alone.

a. Whole Group (S_1 and S_2)

(1) Statistics

It may be seen in Table IV that all predictor systems with two or more SVIB variables had a developmental R which was significant at the .01 level. In addition, all predictor sets containing three or more variables were also significant at this

level. However, the highest cross-validated predictor equation was that containing seven variables. The occupational scales represented by these variables are listed in Appendix H. The refined equation, which is provided in Formula III, had an R value of .60.

TABLE IV

PREDICTED ZQPR CORRELATIONS WITH CRITERION VARIABLE (ZQPR)

VARIABLE	STEP #	DEVELOP R	X - VAL R	REFINED R
VAR115	1	.27*		
VAR114	2	.35**	.46*	
VAR142	3	.39**	.48**	
VAR143	4	.49**	.48**	
VAR131	5	.55**	.51**	
VAR135	6	.59**	.51**	
VAR128	7	.64**	.55**	.60**
VAR146	8	.67**	.52**	
DEGREES FREEDOM		57	28	87

(2) Formulae

The constant and variable weights in the refined equation are listed in Formula III.

Formula III

Predicted ZQPR = X

$$X = -4.303 + 0.028\ (VAR114) - 0.0386\ (VAR115) + 0.0641\ (VAR128) + 0.363\ (VAR131) + 0.061\ (VAR135) - 0.0866\ (VAR142) + 0.0586\ (VAR143)$$

The basic formula for converting predicted ZQPR to raw TQPR is provided by Formula IV-A. Formula IV-B is a simplified and condensed version of the same equation.

Formula IV-A

Converted ZQPR = RT

$$RT = \frac{S'}{S}(X) - \frac{S'}{S}(M) + K$$

$K = 3.17$

$S' = 0.31$

$M = 0.001$

$S = 0.596$

Formula IV-B

$$\boxed{RT = (0.52)X + 3.17}$$

(3) Expectancy Charts

Chart III displays the minimum cutoff scores (predicted raw TQPR's) for each of the cumulative groupings of students from the top 20% to the whole group (ALL). One can see that 58% of those students whose predicted raw TQPR's are 2.86 and above would be expected to attain a superior performance in Aero Engineering.

CHART III

INSTITUTIONAL (CUMULATIVE) EXPECTANCY CHART

Group	Min. Raw TQPR	Per Cent That Will Be Superior (Above Current Median Raw TQPR)
Best 20%	3.39	85%
Best 40%	3.25	78%
Best 60%	3.09	67%
Best 80%	2.86	58%
ALL	No Min. TQPR	50%

Chart IV displays an individuals chances in 100 of being superior in performance. It is interesting to note that a student scoring below 2.86 on this predictor has only a .18 probability of scoring above the median established by the experimental sample group (S).

CHART IV

INDIVIDUAL EXPECTANCY CHART

Predicted Raw TQPR	Chances In 100 Of Being Superior (Above Current Median Raw TQPR)
≥3.39	83
3.25-3.38	72
3.09-3.24	45
2.86-3.08	33
<2.86	18

b. Direct Entry Group (S_{11} and S_{21})

The SVIB data also provided a useful predictor system pertinent only to the direct entry sample.

(1) Statistics

Table V indicates that all predictor sets containing three or more variables had developmental R values which were significant at the .01 level. However, the only predictor system which cross-validated, even at the .05 level of significance was the one containing four variables. The refined equation using these variables with the entire direct entry sample (S_1 + S_2) had a Pearson correlation of .59. The variables used in this equation are listed in Appendix H.

TABLE V

PREDICTED ZOPR CORRELATIONS WITH CRITERION VARIABLE (ZOPR)

VARIABLE	STEP #	DEVELOP R	X - VAL R	REFINED R
VAR142	1	.30		
VAR140	2	.42*	-.03	
VAR104	3	.53**	.22	
VAR158	4	.59**	.50*	.59**
VAR132	5	.65**	.45	
VAR159	6	.70**	.25	
VAR148	7	.74**	.00	
VAR150	8	.78**		
DEGREES FREEDOM		28	14	44

(2) Formulae

The constant and variable weights for this predictor system are displayed in Formula V.

Formula V

Predicted ZQPR = X

$$X = 4.577 - 0.0643\ (VAR104) + 0.0466\ (VAR140) - 0.0745\ (VAR142) - 0.0369\ (VAR158)$$

The basic formula for converting predicted ZQPR(X) to raw TQPR(R) is provided by Formula VI-A and the condensed version of this equation is Formula VI-B

Formula VI-A

Converted ZQPR = RT

$$RT = \frac{S'}{S}(X) - \frac{S'}{S}(M) + K$$

$K = 3.225$

$S' = 0.28$

$M = 0.077$

$S = 0.51$

Formula VI-B

$$RT = 0.55(X) + 3.18$$

(3) Expectancy Charts

Expectancy Chart V displays the minimum cutoff scores for this predictor system for each of the cumulative groupings from the top 20% to the whole group (ALL). One can see that 58% of those whose predicted raw TQPR's are 3.00 and above would be expected to attain a "superior" TQPR in Aero Engineering.

CHART V

INSTITUTIONAL (CUMULATIVE) EXPECTANCY CHART

Group	Min. Raw TQPR	Per Cent That Will Be Superior (Above Current Median Raw TQPR)
Best 20%	3.45	89%
Best 40%	3.31	78%
Best 60%	3.16	63%
Best 80%	3.00	58%
ALL	No Min. TQPR	50%

It may be seen in Chart VI that a student whose predicted raw TQPR is below 3.00 would have only a .20 probability of attaining a superior performance in the Aero Curriculum.

CHART VI

INDIVIDUAL EXPECTANCY CHART

Predicted Raw TQPR	Chances In 100 Of Being Superior (Above Current Median Raw TQPR)
≥3.45	89
3.31-3.44	67
3.00-3.30	39
<3.00	20

4. Biographical and GRE Data

a. Whole Group (S_1 and S_2)

(1) Statistics

The developmental R's in Table VI were significant at the .01 level for all predictor systems developed using from one to eight variables. However, only the formula which contained six variables was significant even at the .05 level. The variables contained in this equation are listed in Appendix H.

TABLE VI

PREDICTED ZQPR CORRELATIONS WITH CRITERION VARIABLE (ZQPR)

VARIABLE	STEP #	DEVELOP R	X - VAL R	REFINED R
VERB	1	.42**	.26	
VAR004	2	.48**	.35	
VAR001	3	.54**	.34	
QUAN	4	.57**	.32	
INDEX	5	.59**	.38	
BQPR	6	.60**	.43*	.55**
VAR006	7	.61**	.38	
VAR003	8	.62**		
DEGREES FREEDOM		47	21	70

(2) Formulae

The constant and variable weights for this predictor system are displayed in Formula VII.

Formula VII

Predicted ZQPR = X

$$X = -4.20 - 0.635\ (VAR001) + 0.691\ (VAR004)$$
$$+0.00184\ (VERB) + 0.00322\ (QUAN)$$
$$+0.00568\ (INDEX) - 1.02\ (BQPR)$$

The basic formula for converting the predicted ZQPR's (X) to raw TQPR values is provided by Formula VIII-A. This equation has been simplified and condensed into Formula VIII-B.

Formula VIII-A

Converted ZQPR = RT

$$RT = \frac{S'}{S}(X) - \frac{S'}{S}(M) + K$$

$K = 3.188$

$S' = 0.301$

$M = 0.018$

$S = .541$

Formula VIII-B

$$\boxed{RT = 0.556(X) + 3.178}$$

(3) Expectancy Charts

Expectancy Chart VII displays the minimum cutoff scores for each of the cumulative groupings of students from the top 20% to the whole group (ALL). One can see that 57% of those students whose predicted raw TQPR's are 2.96 and above would be expected to attain a TQPR in Aero Engineering above the median TQPR of the sample group (S).

CHART VII

INSTITUTIONAL (CUMULATIVE) EXPECTANCY CHART

Group	Min. Raw TQPR	Per Cent That Will Be Superior (Above Current Median Raw TQPR)
Best 20%	3.42	75%
Best 40%	3.28	73%
Best 60%	3.12	64%
Best 80%	2.96	57%
ALL	No Min. TQPR	50%

Chart VIII displays an individual's probability of attaining a "superior performance" according to his predicted raw TQPR. It can be seen that those scoring in the 2.96 to 3.11 range with this predictor system would have a probability of .36 of being superior in performance while those below 2.96 would have only a .21 probability.

CHART VIII

INDIVIDUAL EXPECTANCY CHART

Predicted Raw TQPR	Chances In 100 Of Being Superior (Above Current Median Raw TQPR)
≥3.42	75
3.28-3.41	71
3.12-3.27	43
2.96-3.11	36
<2.96	21

5. Biographical and SVIB Data

The predictor system which was developed using these two types of data produced the highest cross-validated R value of all the equations developed in this research project.

a. Whole Group (S_1 and S_2)

(1) Statistics

Table VII indicates that the predictor sets containing from two to eight variables all had devalopmental R's which were significant at the .01 level and the highest cross-validated R was attained with the predictor which contained six variables. The information which is represented by these variables is listed in Appendix H. Finally, it may be seen that the refined predictor equation produced a Pearson correlation of .60.

TABLE VII

PREDICTED ZQPR CORRELATIONS WITH CRITERION VARIABLE (ZQPR)

VARIABLE	STEP #	DEVELOP R	X - VAL R	REFINED R
VAR004	1	.29*		
VAR108	2	.42**	.51**	
INDEX	3	.49**	.47*	
VAR001	4	.56**	.53**	
VAR115	5	.59**	.65**	.60**
VAR146	6	.63**	.59**	
VAR104	7	.65**	.62**	
VAR102	8	.68**		
DEGREES FREEDOM		53	26	81

(2) Formulae

The constant and variable weights for this predictor system are displayed in Formula IX.

Formula IX

Predicted ZQPR = X

$$X = -1.577 + 0.00212\ (INDEX) - 0.597\ (VAR001) + 0.858\ (VAR004) + 0.0246\ (VAR108) - 0.0295\ (VAR115)$$

The basic formula for converting predicted ZQPR (X) to raw TQPR (RT) is provided by Formula X-A. This equation has been simplified and condensed into Formula X-B.

Formula X-A

Converted ZQPR = RT

$$RT = \frac{S'}{S}(X) - \frac{S'}{S}(M) + K$$

$K = 3.19$

$S' = 0.313$

$M = 0.035$

$S = 0.588$

Formula X-B

$$RT = 0.532\ (X) + 3.17$$

(3) Expectancy Charts

Expectany Chart IX displays the minimum cutoff scores for each of the cumulative groupings of students from the top 20% to the whole group (ALL). Chart IX shows that 61% of those students whose predicted raw TQPR's are 2.96 and above would be expected to attain a "superior performance" in Aero Engineering.

CHART IX

INSTITUTIONAL (CUMULATIVE) EXPECTANCY CHART

Group	Min. Raw TQPR	Per Cent That Will Be Superior (Above Current Median Raw TQPR)
Best 20%	3.45	88%
Best 40%	3.24	72%
Best 60%	3.14	68%
Best 80%	2.96	61%
ALL	No Min. TQPR	50%

Chart X displays an individual's probability of attaining a "superior performance" in Aero according to his predicted raw TQPR with this particular predictor system. Chart X indicates that a student whose predicted raw TQPR is below 2.96 would have only a .06 probability of "being superior" in performance.

CHART X

INDIVIDUAL EXPECTANCY CHART

Predicted Raw TQPR	Chances In 100 Of Being Superior (Above Current Median Raw TQPR)
≥3.45	88
3.24-3.44	59
3.14-3.23	59
2.96-3.13	41
<2.96	6

6. Biographical, GRE, and SVIB Data

A very useful way of predicting performance was also developed using a combination of all three basic types of data.

a. Whole Group (S_1 and S_2)

(1) Statistics

Table IX indicates that all predictors listed had developmental R's which were significant at the .01 level but only those predictors containing eight, nine, or ten variables cross-validated at this level of significance. Although the highest X - VAL R was produced with the formula using nine variables, the equation containing eight variables was used to construct the expectancy charts. This was due to the limitation on the number of variables available in the SNAP computer program.

TABLE IX

PREDICTED ZQPR CORRELATIONS WITH CRITERION VARIABLE (ZQPR)

VARIABLE	STEP #	DEVELOP R	X - VAL R	REFINED R
VERB	1	.43**		
VAR001	2	.49**	.26	
VAR004	3	.55**	.34	
VAR104	4	.59**	.38	
VAR108	5	.65**	.47*	
VAR159	6	.68**	.44*	
VAR141	7	.72**	.49*	
VAR114	8	.77**	.53**	.65**
VAR152	9	.78**	.57**	.70**
VAR132	10	.80**	.53**	.70**
DEGREES FREEDOM		50	21	73

(2) Formulae

The equation containing nine variables is presented in Formula XI and the one with eight variables is presented in Formula XII. The information represented by each of these variables may be found in Appendix H.

Formula XI

PREDICTED ZQPR = X (NINE VARIABLES INCLUDED)

X = -4.92 + 0.00171 (VERB) - 0.49 (VAR001)
+1.114 (VAR004) - 0.0628 (VAR104)
+0.067 (VAR108) + 0.0281 (VAR114)
+0.062 (VAR141) + 0.0357 (VAR152)
-0.0224 (VAR159)

Formula XII

PREDICTED ZQPR = X (EIGHT VARIABLES INCLUDED)

X = -3.066 + 0.00225 (VERB) - 0.455 (VAR001)
+1.042 (VAR004) - 0.0545 (VAR104)
+0.0716 (VAR108) + 0.0236 (VAR114)
+0.0392 (VAR141) - 0.233 (VAR159)

The basic formula for converting predicted ZQPR (X) to raw TQPR (RT) is provided by Formula XIII-A. A simplified and condensed version of this equation is Formula XIII-B.

Formula XIII-A

Converted ZQPR = R

$$RT = \frac{S'}{S}(X) - \frac{S'}{S}(M) + K$$

K = 3.17

S' = 0.31

M = -0.026

S = 0.62

Formula XIII-B

$$RT = 0.5(X) + 3.19$$

(3) Expectancy Charts

Chart XI indicates that 62% of those in a group whose predicted raw TQPR's, according to this predictor system, are 2.93 and above would be expected to "be superior" in performance in the Aero Program.

CHART XI

INSTITUTIONAL (CUMULATIVE) EXPECTANCY CHART

Group	Min. Raw TQPR	Per Cent That Will Be Superior (Above Current Median Raw TQPR)
Best 20%	3.42	87%
Best 40%	3.22	77%
Best 60%	3.09	72%
Best 80%	2.93	62%
ALL	No Min. TQPR	50%

Chart XII indicates that all those attaining a predicted raw TQPR below 2.93 on this predictor system would have a zero probability of "being superior" in performance in the Aero Curriculum. This predictor may be very useful for counseling students who are considering enrollment in the program.

CHART XII

INDIVIDUAL EXPECTANCY CHART

Predicted Raw TQPR	Chances In 100 Of Being Superior (Above Current Median Raw TQPR)
≥3.42	87
3.22-3.41	69
3.09-3.21	63
2.93-3.08	30
<2.93	0

C. PREDICTORS OF SATISFACTION

Each of the three basic types of data (biographical, GRE, and SVIB), and all possible combinations thereof, were used in the development of predictors of satisfaction. However, no predictor systems which cross-validated at the .05 level of significance were discovered.

This failure to develop successful predictors of SN may have been the result of the criterion measure itself. It was previously explained that the value for each student's SN was determined by using the yes/no answers to only four of the questions in the biographical questionnaire. In retrospect, it appears that a longer, more detailed questionnaire (or other procedure), employing a scale which indicates varying degrees of SN should be used.

Since no formulae for the prediction of SN cross-validated, the researcher combines the developmental and cross-validation samples (S_1 and S_2) into one large developmental sample. This resulted in a face valid formula with a developmental r which was significant at the .01 level. Variable names and their meanings are listed in Appendix H.

1. Statistics

TABLE X

PREDICTED SN CORRELATIONS WITH CRITERION (SN)

VARIABLE	STEP #	DEVELOP R
VAR019	1	.45**
VAR111	2	.55**
QPR4	3	.59**

2. Formulae for Predicted SN

Since the R values for all three steps of the regression were significant at the .01 level the formulae for each of these steps are included.

a. One Variable Formula

$$SN = 1.083 + 1.891(VAR019)$$

b. Two Variable Formula

$$SN = 0.071 + 1.649(VAR019) + 0.0368(VAR111)$$

c. Three Variable Formula

$$SN = -1.532 + 1.427(VAR019) + 0.0318(VAR111) + 0.697(QPR4)$$

The reader is reminded that the equations above have not been cross-validated.

VI. SUMMARY AND CONCLUSIONS

The objectives of this research project were the development of predictors of performance and satisfaction for the Aero Engineering students at NPS. Six formulae for the prediction of performance were successfully developed and no predictors of satisfaction which would cross-validate were discovered. However, a face valid predictor of SN was developed using the whole sample group as the developmental sample.

Four of the performance prediction equations were developed with the entire sample group (S_1 and S_2), and two applied only to the direct entry sample. Each of these prediction equations is briefly discussed in the following paragraphs. The applicable formulae may be found in the Data Analysis section of this thesis.

A. PERFORMANCE PREDICTORS

1. Biographical Data Only

One predictor system, applicable to the entire sample group, was developed with these data. This system should be useful due to the relative ease with which this type of information can be obtained. The variables and variable weights included in this formula are listed in Table XI.

TABLE XI

ENTIRE SAMPLE
VARIABLES IN PREDICTOR USING BIO DATA ONLY

WEIGHTS	+ -	VARIABLE	INFORMATION
.00251	+	INDEX	SELF REPORTED-BACCALAUREATE QPR TIMES COLLEGE QUALITY (BQPR x QUAL)
.519	-	VAR001	NAVAL ACADEMY
.635	+	VAR004	LT OR BELOW
.850	-	VAR005	B.S. DEGREE

2. SVIB Data Only

Two predictors of performance were developed with these data. One is applicable to the entire sample and the other to the direct entry sample. The SVIB data produced the highest cross-validated equations of any of the three basic types of data used alone. The variables included in each of the two equations are listed in Tables XII and XIII.

TABLE XII

ENTIRE SAMPLE
VARIABLES IN PREDICTOR USING SVIB DATA ONLY

WEIGHT	VARIABLE	+ -	OCCUPATION
.0280	VAR114	+	AIR FORCE OFFICER
.0386	VAR115	-	FOREST SERVICE
.0641	VAR128	+	ARTIST
.3630	VAR131	+	CPA OWNER
.0610	VAR135	+	CREDIT MANAGER
.0866	VAR142	-	SALES MANAGER
.0586	VAR143	+	REAL ESTATE SALESMAN

TABLE XIII

DIRECT ENTRY SAMPLE
VARIABLES IN PREDICTOR USING SVIB DATA ONLY

WEIGHT	VARIABLE	+ -	OCCUPATION
.0643	VAR104	-	OSTEOPATH
.0466	VAR140	+	PHARMACIST
.0745	VAR142	-	SALES MANAGER
.0369	VAR158	-	NROTC RETENTION

3. Biographical and GRE Data

This particular combination of data provided one of the more face-valid ways of predicting performance examined in this research. The variables included in this formula for the entire sample group are displayed in Table XIV.

TABLE XIV

ENTIRE SAMPLE
VARIABLES IN PREDICTOR USING BIO + GRE DATA

WEIGHT	VARIABLE	+ -	INFORMATION
.635	VAR001	-	NAVAL ACADEMY
.691	VAR004	+	LT OR BELOW
.00184	VERB	+	GRE VERBAL SCORE
.00322	QUAN	+	GRE QUANTITATIVE SCORE
.00568	INDEX	+	(BQPR x QUAL)
1.020	BQPR	-	SELF REPORTED BACCALAUREATE QPR

4. Biographical and SVIB Data

The highest cross-validation (R = .65) of all predictor systems developed was achieved with this combination of data types.

The variables in this formula, applicable to the entire sample, are listed in Table XV.

TABLE XV

ENTIRE SAMPLE
VARIABLES IN PREDICTOR USING BIO + SVIB DATA

WEIGHT	VARIABLE	+ -	INFORMATION
.00212	INDEX	+	(BQPR x QUAL)
.597	VAR001	-	NAVAL ACADEMY
.858	VAR004	+	LT OR BELOW
.0246	VAR108	+	PSYCHOLOGIST
.0295	VAR115	-	FOREST SERVICE

5. Biographical, GRE, and SVIB Data

An equation for predicting performance was developed using the entire sample group. This equation employed a combination of all three basic types of predictor data. The variables used in the resulting prediction formula are displayed in Table XVI.

TABLE XVI

ENTIRE SAMPLE
VARIABLES IN PREDICTOR USING BIO + GRE + SVIB DATA

WEIGHT	VARIABLES	+ -	INFORMATION/OCCUPATION
.00171	VERB	+	GRE VERBAL SCORE
.490	VAR001	-	NAVAL ACADEMY
1.114	VAR004	+	LT OR BELOW
.0628	VAR104	-	OSTEOPATH
.0670	VAR108	+	PSYCHOLOGIST
.0281	VAR114	+	AIR FORCE OFFICER
.0620	VAR141	+	MORTICIAN
.0357	VAR152	+	ACADEMIC ACHIEVEMENT
.0224	VAR159	-	MANAGERIAL EFFECTIVENESS

The presence of the SVIB variables "Osteopath" and "Mortician" are quite conspicuous in this predictor system. At this point the researcher could only speculate as to the reasons for this occurrence.

B. SATISFACTION PREDICTORS

Although none of the predictors of satisfaction cross-validated at the statistically significant level, a predictor equation for predicting this criterion variable was produced using the entire (developmental + cross-validation) sample.

1. Statistics

TABLE XVII

ENTIRE SAMPLE
VARIABLES IN PREDICTION OF SN

VARIABLE	+ -	WEIGHT	INFORMATION
VAR019	+	1.427	First or Second Choice
VAR111	+	0.0318	SVIB Engineering Scale
QPR4	+	0.6970	Fourth Year Bac. QPR

It should be remembered that this predictor system has not been cross-validated.

C. CONCLUSIONS

The predictors of academic performance which have been developed in this research project should provide useful tools for selection and/or counseling of personnel for the Aero Program. Due to the restriction of range associated with sample group S it is suggested that any use of these predictors for selection purposes be made in addition to the present BUPERS selection procedures.

The predictor of satisfaction developed in this project should not be used until it has been checked for predictive validity with a subsequent sample group. In addition, the method used in this research to measure the criterion variable, satisfaction, may be suspect. Finally, a lack of longitudinal stability of satisfaction may exist thus making a prediction of this type infeasible.

VII. SUGGESTIONS FOR FUTURE RESEARCH

Several suggestions which may produce fruitful and interesting results are offered for future research. First, it is recommended that another type of performance predictor which may be obtainable is a measure of students' motivation to study. Secondly, one might check the predictive validity [6] of the predictor systems developed in this research project with subsequent student sample groups. In addition, a similar analysis of these data with sample group S divided into Naval Academy and non-Naval Academy subgroupings may prove interesting.

Future research pertinent only to satisfaction might include a measurement of satisfaction employing a method which would provide degrees or levels of satisfaction; e.g., Likert [9] type scale. Finally, one might consider checking the longitudinal stability of satisfaction during curricular enrollment. This could be done with little effort by using the same four questions which were used in this project.

APPENDIX A

GRADUATE EDUCATION POTENTIAL CLASSIFICATION REQUIREMENTS

1. Capable of direct entry into a technical curriculum.

   1) Possess an accredited baccalaureate degree with a minimum preparation of mathematics through the differential and integral calculus of several variables and a one year course in general physics using calculus as a tool. Marks achieved in all mathematics and physics courses be C or better and the overall average of these grades at least 2.50 on a scale having 2.00 as C.

   2) When academic credits include college chemistry or engineering credits taken in the junior or senior year, an overall average of 2.50 or better in all math, physics, chemistry and upper division engineering may be substituted for the required overall average in math and physics.

2. Capable of direct entry into a non-technical graduate program not requiring mathematical aptitude.

   1) Possess an accredited baccalaureate degree with an overall average of at least 2.75 on a scale having 2.00 as C.

   2) Have an academic major in a non-technical subject with an average of at least 3.00 in that subject. A general liberal arts degree with a 2.00 average may be used as a substitute if no major was pursued.

3. Potentially capable of entry into a technical curriculum after a refresher course of 3-6 months duration.

   1) Possess an accredited baccalaureate degree.

   2) Have passed mathematics courses through the differential and integral calculus of several variables and a one year course in general physics using calculus as a tool. Have at least a 2.00 average in all mathematics and physics courses.

   3) When courses of 2) have been taken, a GRE Quantitative Aptitude score of 550 or higher may be substituted for the 2.00 average.

4. Capable of direct entry into a non-technical graduate program requiring some mathematical aptitude.

   1) Possess an accredited baccalaureate degree with an overall average of at least 2.50 on a scale having 2.00 as a C average.

   2) Have completed successfully (C grades at least) a minimum of two college courses in mathematics at the level of college algebra or higher and have a Graduate Record Examination (GRE) Quantitative Aptitude score of 500 or higher.

   3) A GRE Quantitative Aptitude score of 550 or higher may be used in lieu of criteria 2).

5. Entry into an updating program which may lead to Qualification for a technical curriculum after 6 to 12 months of study.

   1) Possess an accredited baccalaureate degree.

   2) Have completed successfully (at least a C grade) at least one college mathematics course in algebra, trigonometry, or math analysis.

   3) When no college mathematics has been taken, a baccalaureate degree with an overall average of 2.75, where 2.00 is a C average, or a GRE Quantitative Aptitude score of 550 may be substituted.

6. Could qualify for category 5 by taking off-duty courses.

   1) Possess an accredited baccalaureate degree.

   2) No evidence of mathematical inadequacy in form of low marks in courses attempted.

7. No apparent potential for graduate education.

   1) Possess an accredited baccalaureate degree.

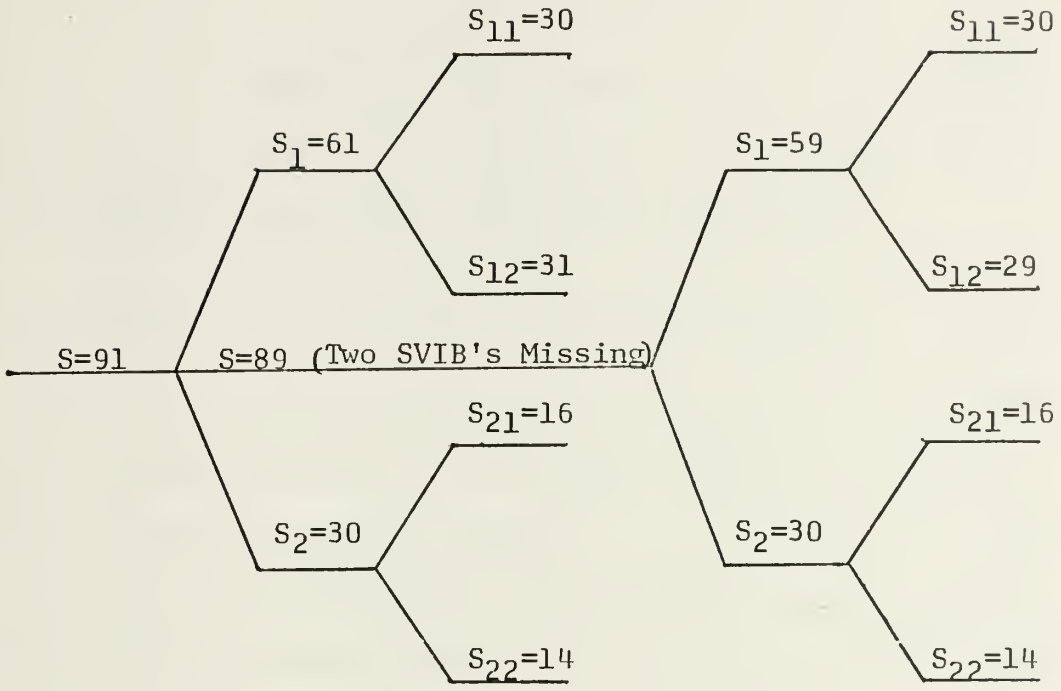
   2) Not qualified in categories 1-5.

   3) Evidence of mathematical inadequacy by low marks in courses attempted.

8. No accredited baccalaureate degree.

APPENDIX B

SAMPLE GROUP FORMATION



S = Entire Sample

S_1 = Developmental Sample

S_{11} = Direct Entry Developmental Sample

S_{12} = Eng. Science Developmental Sample

S_2 = Cross Validation Sample

S_{21} = Direct Entry Cross Validation Sample

S_{22} = Eng. Science Cross Validation Sample

APPENDIX C

BIOGRAPHICAL QUESTIONNAIRE

Biographical Questions	S_1 N=61 Yes/No	S_2 N=30 Yes/No
1. Did you receive your commission from the USNA?..	25/36	12/18
2. Did you receive your commission through an ROTC program?.....	14/47	5/25
3. Have you ever been an enlisted man in any service?.....	14/47	8/22
4. Is your rank Navy Lieutenant or below?.....	49/12	23/7
5. Are you a pilot or other flight officer?.....	60/1	30/0
6. Are you a submarine officer?.....	0/61	0/30
7. Are you an unrestricted line officer?.....	52/9	27/3
8. Are you a staff officer?.....	0/61	0/30
9. Do you have a B.S. (not a B.A.) degree?.....	58/3	28/2
10. Have you had at least one year of college calculus at an institution other than the Naval Postgraduate School?.....	58/3	28/2
11. Do you speak at least one language other than English?.....	16/45	4/26
12. Do you have a master's degree from a school other than the Naval Postgraduate School?.....	2/59	1/29
13. Have you taken any graduate courses other than at the Naval Postgraduate School?.....	10/51	4/26
14. Have you ever completed any courses at night school or through correspondence?.....	26/35	15/15
15. As an undergraduate in college, did you have an A or A- average?.....	6/55	2/28

Biographical Questions	S_1 N=61 Yes/No	S_2 N=30 Yes/No
16. Was your undergraduate average in college below B-?	21/40	15/15
17. Do you need to wear glasses for reading?	9/52	3/27
18. Are you five feet nine inches or shorter?	20/41	7/23
19. Are you 172 pounds or heavier?	29/32	21/9
20. Are you white (Caucasian)?	60/1	30/0
21. Are you black (Negro)?	0/61	1/29
22. Was a branch of engineering your undergraduate major in college?	46/15	26/4
23. Are you Roman Catholic?	18/43	10/20
24. Are you Protestant?	38/23	17/13
25. Have you ever been divorced?	4/57	2/28
26. Are you married now?	55/6	26/4
27. Do you have any sons?	32/29	16/14
28. Do you have any daughters?	34/27	18/12
29. Do you have any older brothers or sisters?	26/35	12/18
30. Do you have any younger brothers or sisters?	43/18	18/12
31. Is your father a college graduate?	24/37	8/22
32. Has your mother ever attended college?	23/38	14/16
33. Do you have a wife who is a college graduate?	27/34	12/18
34. Is or was your father a career military officer?	11/50	4/26
35. Is or was your father a career military enlisted man?	0/61	1/29
36. Did you spend more than one year of your childhood on a farm?	5/56	6/24

Biographical Questions	S_1 N=61 Yes/No	S_2 N=30 Yes/No
37. Did you take a college-preparatory program in high school?	46/15	22/8
38. Were you in the upper one-quarter of the college-preparatory students in your class at high school?	43/18	18/12
39. Do you smoke cigarettes, cigars, or a pipe?	23/38	14/16
40. Are you currently a student at any graduate school other than the Naval Postgraduate School?	1/60	0/30
41. Are you a student at the Naval Postgraduate School?	61/0	30/0
42. Would you say that you typically drink an alcoholic beverage daily other than at mealtime?	14/47	6/24
43. Do you typically drink more than five cups of coffee a day?	32/29	7/23
44. Are you younger than 30 years of age?	32/29	15/15
45. Would you expect to use any skills learned in graduate school in subsequent assignments in the Navy?	47/14	27/3
46. Do you expect to use any graduate education obtained while on active duty in work after you retire from the Navy?	48/13	24/6
47. Do you wish to serve in a billet requiring the education that you would receive at a graduate school (P-coded billet)?	43/18	24/6
48. Would you prefer to do your graduate work at a school other than the Naval Postgraduate School?	34/27	11/19
49. Do you believe that postgraduate education will increase your chances for promotion?	41/20	20/10
50. Were you last designated a principal or an alternate (as opposed to neither) by the Postgraduate Selection Board?	51/10	23/7

Biographical Questions	S_1 N=61 Yes/No	S_2 N=30 Yes/No
51. Have you ever been a patrol leader or a senior patrol leader in the Boy Scouts?	25/36	9/21
52. Have you been a Star Scout or above in the Boy Scouts?	17/44	6/24
53. Have you ever taken lessons for a musical instrument for longer than two consecutive years?	32/29	17/13
54. Do you now play a musical instrument?	12/49	6/24
55. Are you satisfied with your education at the Naval Postgraduate School?	42/19	26/4
56. Are or were you in the curriculum of your first or second choice?	52/9	27/3
57. Were you ever in the baccalaureate program?	5/56	5/25
58. Have you ever spent time in the engineering science curriculum?	29/32	16/14
59. Do you now like your degree curriculum?	42/19	22/8
60. Would you choose a different degree curriculum if you could start over again?	27/34	14/16
61. Was at least part of your motivation to remain in the Navy the opportunity to receive Postgraduate education?	30/31	15/15

APPENDIX D

OCCUPATIONAL AND NON-OCCUPATIONAL SCALES

A. OCCUPATIONAL SCALES	STD MEAN	STD SD	RAW MEAN	RAW SD
Occupation				
1. Naval Officer	46.78	9.29	117.72	6.00
2. Physical Therapist	37.45	10.24	107.64	11.47
3. Dentist	28.28	9.14	95.26	12.42
4. Osteopath	30.07	8.75	97.00	7.38
5. Veterinarian	28.24	8.33	97.63	10.22
6. Physician	31.78	10.60	101.12	9.05
7. Psychiatrist	24.60	11.92	98.71	11.64
8. Psychologist	27.16	10.14	97.11	13.16
9. Biologist	29.98	12.20	105.00	15.50
10. Architect	29.81	11.71	102.30	21.94
11. Engineer	33.12	12.19	106.51	17.66
12. Production Manager	38.59	8.69	102.37	8.32
13. Army Officer	42.20	8.93	120.75	9.69
14. Air Force Officer	42.78	8.19	125.09	14.45
15. Forest Service	28.87	9.57	109.18	9.06
16. Farmer	35.80	8.31	102.23	12.60
17. Math-Science Teacher	31.53	8.22	98.18	8.32
18. Printer	28.47	8.65	93.08	10.13
19. Policeman	23.33	7.60	94.73	9.13
20. Personnel Director	24.86	11.27	94.86	9.23
21. Public Administrator	36.55	10.20	102.70	8.37

Occupation	STD MEAN	STD SD	RAW MEAN	RAW SD
22. Rehabilitation Counselor	27.75	9.91	93.11	12.66
23. YMCA Secretary	26.75	13.04	97.96	19.45
24. Recreation Administrator	29.61	13.62	107.86	21.56
25. Social Worker	24.38	12.29	95.37	16.12
26. Social Science Teacher	21.54	11.27	87.08	13.33
27. Librarian	23.36	8.12	89.68	12.35
28. Artist	27.32	9.28	84.95	23.29
29. Music Performer	30.72	8.18	90.30	9.11
30. Music Teacher	21.58	8.87	89.06	9.72
31. CPA Owner	21.35	8.27	91.18	7.77
32. Senior CPA	31.13	9.95	104.81	7.94
33. Accountant	25.35	8.97	95.07	6.88
34. Office Worker	24.35	9.37	88.95	9.33
35. Credit Manager	29.13	12.08	96.10	17.96
36. Chamber of Commerce	31.49	9.14	92.31	18.43
37. Business Education Teacher	27.66	10.97	88.74	14.74
38. Purchasing Agent	32.03	10.12	93.28	12.66
39. Banker	22.86	8.68	85.88	11.54
40. Pharmacist	24.67	7.79	86.39	8.71
41. Mortician	26.20	7.46	83.07	11.04
42. Sales Manager	22.45	9.58	84.91	11.58
43. Real Estate Salesman	30.79	7.82	84.68	12.73
44. Life Insurance Salesman	21.17	8.31	76.75	13.05
45. Advertising Man	23.84	7.71	75.98	14.20
46. Attorney	26.38	8.11	87.31	12.66

	Occupation	STD MEAN	STD SD	RAW MEAN	RAW SD
47.	Author-Journalist	27.56	7.99	68.85	23.98
48.	President Mfg. Concern	21.41	8.96	88.80	8.48
49.	Computer Programmer	43.44	10.30	118.73	8.32
50.	Interpreter	25.26	9.62	95.69	10.57
51.	Mathematician	21.95	11.06	91.31	21.73
52.	Physicist	25.39	12.67	101.59	23.85
53.	Chemist	34.92	13.11	109.57	14.56
54.	Carpenter	29.66	10.92	104.74	16.91
55.	School Superintendent	15.77	11.05	87.33	11.84

B. NON-OCCUPATIONAL SCALES

	Area of Interest	STD MEAN	STD SD	RAW MEAN	RAW SD
1.	Doctor A-B	42.22	10.83	89.59	11.29
2.	Academic Achievement	45.84	10.50	105.21	10.77
3.	Liberal-Conservative	41.03	8.05	91.61	6.12
4.	Masculinity-Femininity	54.79	7.10	113.36	13.57
5.	Occupational Level	57.32	6.66	115.54	8.30
6.	Extroversion Introversion	48.92	11.39	88.51	20.25
7.	Sepcialization Level	41.34	8.65	104.24	5.29
8.	NROTC Retention	54.78	9.46	106.36	9.51
9.	Managerial Effectiveness	49.09	10.54	109.28	8.43

APPENDIX E

BQPR/ABQPR DATA

A. TRISERIAL CORRELATION (r_{tri})

$$r_{tri} = \frac{Z_a Y_a + (Z_b - Z_a) Y_b - Z_b Y_c}{\sigma_y \left[Z_a^2 + \frac{(Z_b - Z_a)^2}{b} + \frac{Z_b^2}{c} \right]}$$

where X = continuous segmented variable

Y = continuous variable

a = proportion of cases in top segment of X

b = proportion of cases in second highest segment of X

c = proportion of cases in third highest segment of X

$q_a = a$

$q_b = a + b$

$q_c = a + b + c$

z_a = ordinate of the normal curve at q_a

z_b = ordinate of the normal curve at q_b

z_c = ordinate of the normal curve at q_c

y_a = mean of y's in top segment of X distribution

y_b = mean of y's in second highest segment of X distribution

y_c = mean of y's in third highest segment of X distribution

σ_y = standard deviation of Y distribution

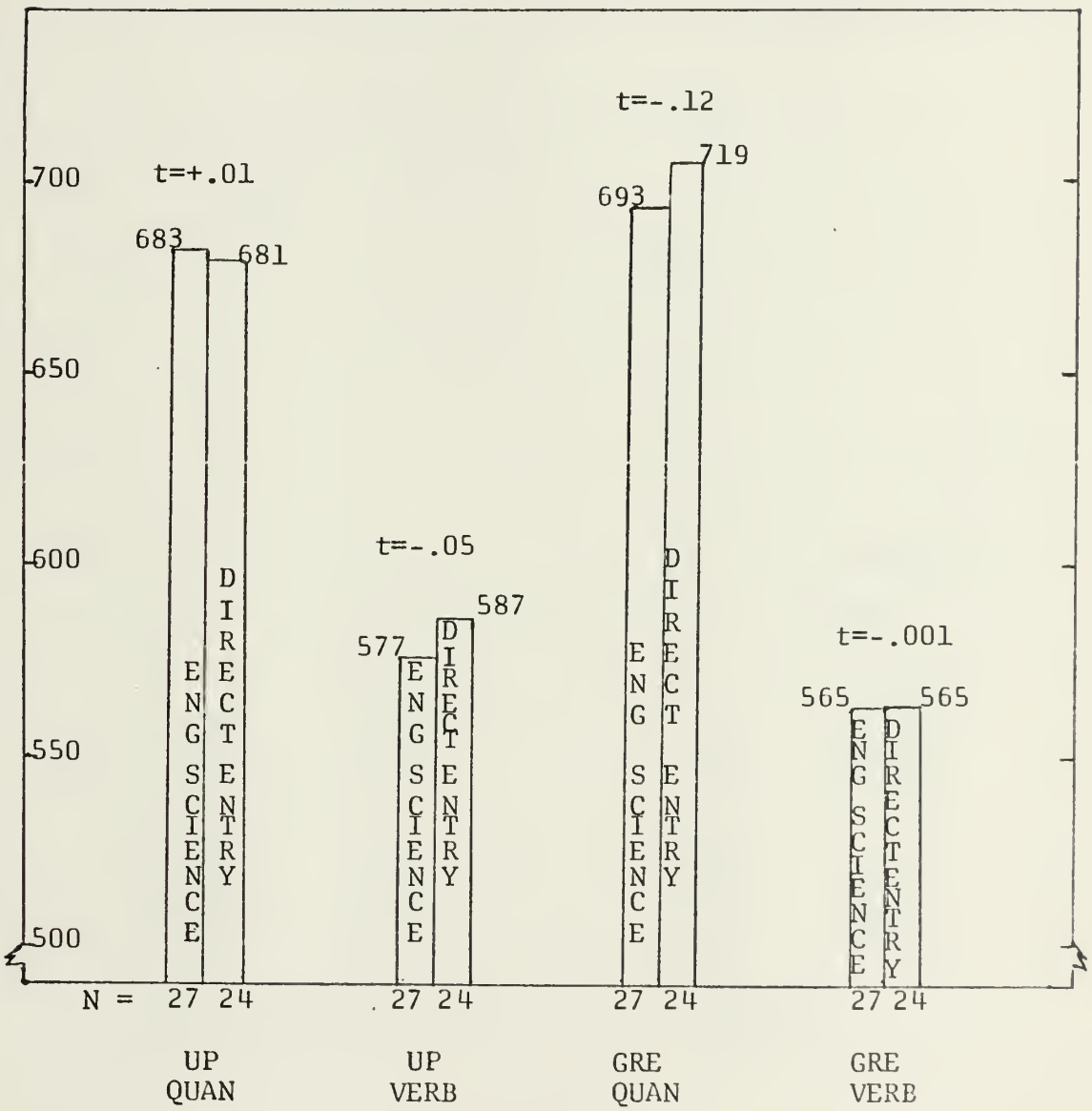
B. MATCHED BQPR AND ABQPR DATA

BQPR	ABQPR	BQPR	ABQPR
2.30	2.01	2.30	2.00
3.00	2.43	2.30	2.40
2.30	2.17	2.30	3.00
3.00	2.95	3.00	2.63
3.00	2.25	3.00	2.30
2.30	2.22	2.30	2.70
3.00	2.75	3.00	2.65
2.30	2.04	3.00	2.70
3.00	3.44	2.30	2.30
2.30	2.10	2.30	2.01
2.30	2.35	2.30	2.64
2.30	2.55	3.00	2.60
3.00	3.18	2.30	2.17
3.00	3.03	3.00	3.15
3.00	2.89	3.00	2.91
2.00	2.95	3.00	2.81
2.30	2.60	3.00	2.97
3.00	2.62	3.70	3.73
3.70	3.45	3.00	3.00
3.00	3.32	3.70	3.64
3.00	2.50	3.00	3.15
3.00	2.78	2.30	2.24
2.30	2.62	3.00	2.50
3.00	2.43	2.30	2.70
2.30	2.34	2.30	2.98
3.00	2.67	3.00	3.31
3.00	2.77	2.30	2.57
3.00	2.40	2.30	2.71
3.00	2.53	3.00	2.91
3.00	2.47	3.00	2.50
3.00	2.89	3.00	3.00
3.00	2.68	3.00	3.33
3.70	3.11	3.00	2.83
2.30	2.58	2.30	2.50
2.30	2.50	3.70	3.47
3.00	3.12	3.00	3.12
2.30	2.18	2.30	2.00
2.30	2.54	3.00	2.62
3.00	3.20	3.70	2.68
2.30	2.18	3.00	3.04
2.30	2.27		

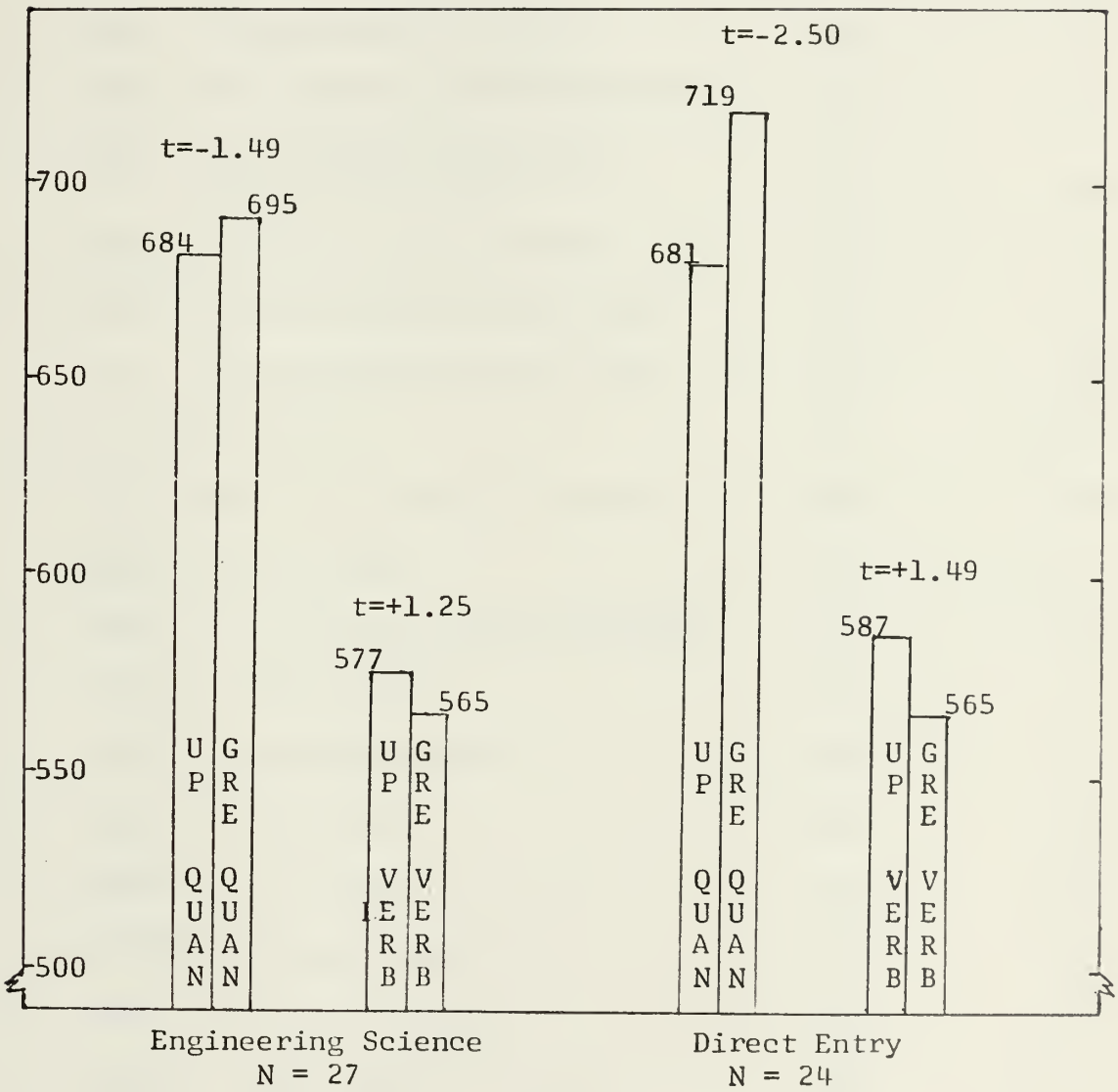
APPENDIX F

GRE/UP COMPARISONS

A. GRE and UP Data: Engineering Science vs Direct Entry



B. Direct Entry and Engineering Science Data: UP vs GRE



APPENDIX G

PEARSON CORRELATIONS BETWEEN CRITERION AND PREDICTOR VARIABLES

A. PEARSON CORRELATIONS OF BIOGRAPHICAL VARIABLES WITH ZQPR AND AND SN FOR WHOLE SAMPLE GROUP.

	Variable	r with ZQPR	r with SN
1.	QUAL - College Quality Rating	-.019	- .061
2.	BQPR - Self Reported Baccalaureate QPR	.180	.161
3.	ABQPR - Historically Documented Baccalaureate QPR	.124	.380
4.	PQPR - QPR in Pertinent Courses	.098	.270
5.	QPR3 - 3rd Year Undergraduate QPR	.120	.267
6.	QPR4 - 4th Year Undergraduate QPR	.059	.391
7.	SN - Satisfaction	.243	1.000
8.	CUS - Number of Pertinent Courses	.096	.010
9.	INDEX - BQPR X QUAL	.190	.124
10.	VAR001 - U.S. Naval Academy Graduate	.187	- .007
11.	VAR002 - ROTC Graduate	.227	.027
12.	VAR003 - Enlisted Service	.002	.005
13.	VAR004 - LT or Below	.296	.065
14.	VAR005 - B.S. Degree	.246	.082
15.	VAR006 - College Calculus	.030	.053
16.	VAR007 - Foreign Language	.096	.032
17.	VAR011 - Undergraduate A or A-	.169	.144
18.	VAR012 - Undergraduate below B-	-.131	- .122
19.	VAR013 - Undergraduate Engineering	.151	- .008
20.	VAR014 - Less Than 30 Years Old	.217	.084
21.	VAR015 - Service Billet Requiring Education at NPS	.261	.650

	Variable	r with ZQPR	r with SN
22.	VAR016 - Satisfied with NPS Education?	.186	.793
23.	VAR017 - Do you like your Curriculum?	.167	.883
24.	VAR018 - Desire different Curriculum?	-.142	- .764
25.	VAR019 - Curriculum of 1st 2nd choice?	-.003	.446

B. PEARSON CORRELATIONS OF GRE VARIABLES WITH ZQPR or SN FOR WHOLE SAMPLE GROUP.

Variable	r with ZQPR	r with SN
GRE VERB	.262	.179
GRE QUAN	.322	.210

C. PEARSON CORRELATIONS OF SVIB VARIABLES (STANDARDIZED SCORES) WITH ZQPR AND SN FOR WHOLE SAMPLE GROUP.

	Variable		r with ZQPR	r with SN
1.	VAR101	Naval Officer	-.000	.060
2.	VAR102	Physical Therapist	-.076	.064
3.	VAR103	Dentist	-.027	.149
4.	VAR104	Osteopath	-.020	.059
5.	VAR105	Veterinarian	-.295	-.070
6.	VAR106	Physician	.019	.103
7.	VAR107	Psychiatrist	.133	.166
8.	VAR108	Psychologist	.275	.221
9.	VAR109	Biologist	.106	.270

		Variable	r with ZQPR	r with SN
10.	VAR110	Architect	.018	.209
11.	VAR111	Engineer	.046	.386
12.	VAR112	Production Manager	-.077	.218
13.	VAR113	Army Officer	-.011	.155
14.	VAR114	A.F. Officer	.102	.274
15.	VAR115	Forest Service	-.346	-.178
16.	VAR116	Farmer	-.225	.109
17.	VAR117	Math-Science Teacher	-.055	.164
18.	VAR118	Printer	-.028	.090
19.	VAR119	Policeman	-.219	-.038
20.	VAR120	Personnel Director	-.073	-.058
21.	VAR121	Public Administrator	.017	-.009
22.	VAR122	Rehabilitation Couns.	.091	-.127
23.	VAR123	YMCA Secretary	-.056	-.280
24.	VAR124	Recreation Administrator	-.078	-.275
25.	VAR125	Social Worker	.020	-.179
26.	VAR126	Social Science Teacher	-.104	-.350
27.	VAR127	Librarian	.149	-.091
28.	VAR128	Artist	.055	.092
29.	VAR129	Music Performer	.003	-.145
30.	VAR130	Music Teacher	.056	-.254
31.	VAR131	CPA Owner	.270	.069
32.	VAR132	Senior CPA	.131	.082
33.	VAR133	Accountant	.057	.217
34.	VAR134	Office Worker	-.018	-.124
35.	VAR135	Credit Manager	.017	-.127

			r with ZQPR	r with SN
36.	VAR136	Chamber Commerce	.007	-.209
37.	VAR137	Business Education Teacher	.043	-.258
38.	VAR138	Purchasing Agent	-.024	.079
39.	VAR139	Banker	-.083	-.143
40.	VAR140	Pharmacist	-.102	-.020
41.	VAR141	Mortician	-.045	-.164
42.	VAR142	Sales Manager	-.140	-.179
43.	VAR143	Real Estate Salesman	-.062	-.344
44.	VAR144	Life Ins. Salesman	-.072	-.371
45.	VAR145	Advertising Man	.026	-.260
46.	VAR146	Attorney	.020	-.178
47.	VAR147	Author-Journalist	.066	-.081
48.	VAR148	President Mfg. Concern	-.075	.019
49.	VAR149	Computer Programmer	.257	.355
50.	VAR150	Interpreter	.157	-.191
51.	VAR151	Doctor A-13	.038	-.180
52.	VAR152	Academic Acheivement	.226	.200
53.	VAR153	Liberal-Conservative	.148	-.189
54.	VAR154	Masculinity-Feminity	-.095	.317
55.	VAR155	Occupational Level	.115	.063
56.	VAR156	Extroversion-Introver.	.083	.190
57.	VAR157	Specialization Level	.168	.233
58.	VAR158	NROTC Retention	-.132	.165
59.	VAR159	Managerial Effectiveness	.035	-.013

	Variable	r with ZQPR	r with SN
60.	VAR160 Mathematician	.091	.226
61.	VAR161 Physicist	.115	.337
62.	VAR162 Chemist	.161	.382
63.	VAR163 Carpenter	-.008	.187
64.	VAR164 School Superintendent	.077	.131

APPENDIX H

PREDICTOR VARIABLES

A. BIOGRAPHICAL VARIABLES

VARIABLE	QUESTION/INFORMATION
BQPR	SELF REPORTED BACCALAUREATE QPR
QPR4	FOURTH YEAR BACCALAUREATE QPR
INDEX	BQPR TIMES COLLEGE QUALITY (QUAL)
VAR001	RECEIVE COMMISSION FROM USNA?
VAR004	LIEUTENANT OR BELOW?
VAR005	B.S. DEGREE

B. GRE VARIABLES

VARIABLE	
QUAN	GRE QUANTITATIVE APTITUDE SCORE
VERB	GRE VERBAL APTITUDE SCORE

C. SVIB VARIABLES

VARIABLE	OCCUPATION SCALE
VAR104	OSTEOPATH
VAR108	PSYCHOLOGIST
VAR111	ENGINEER
VAR114	AIR FORCE OFFICER
VAR115	FOREST SERVICE
VAR128	ARTIST
VAR131	CPA OWNER
VAR135	CREDIT MANAGER
VAR140	PHARMACIST
VAR141	MORTICIAN
VAR142	SALES MANAGER
VAR143	REAL ESTATE SALESMAN
VAR158	NROTC RETENTION
VAR159	MANAGERIAL EFFECTIVENESS

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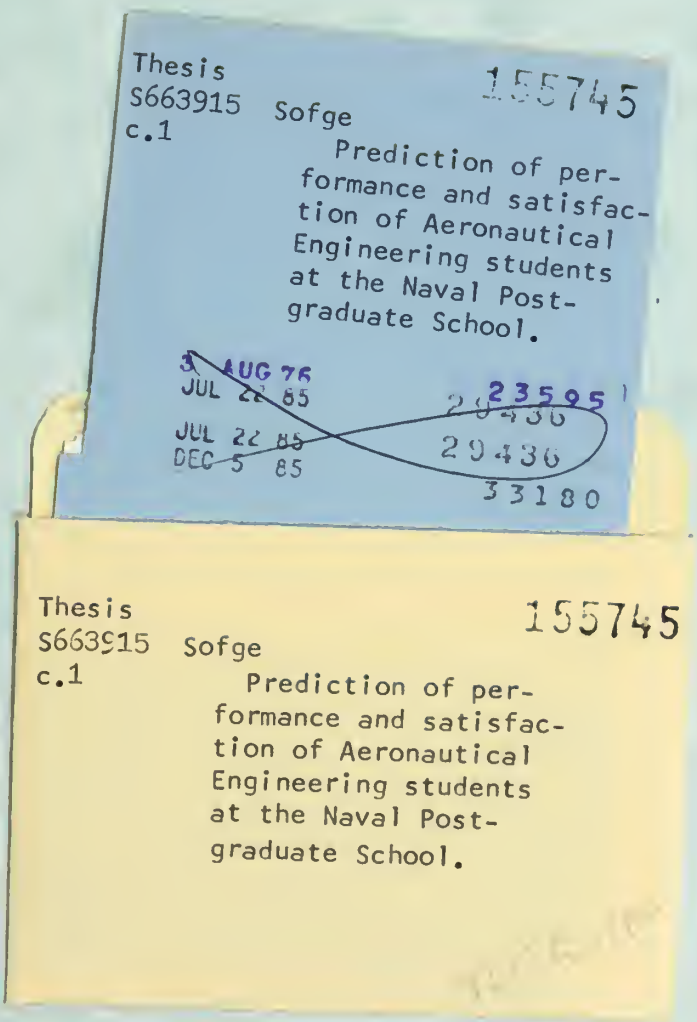

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